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Empirical estimation of beam-on time for prostate cancer patients treated on Tomotherapy

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Purpose/Objective: This study proposed a method to estimate the beam-on time for prostate cancer patients treated on Tomotherapy when FW (field width), PF (pitch factor), modulation factor (MF) and treatment length (TL) were given.

Materials and Methods: The study was divided into two parts: building and verifying the model. To build a model, 160 treatment plans were created for 10 patients. The plans differed in combination of FW, PF and MF. For all plans a graph of beam-on time as a function of TL was created and a linear trend function was fitted. Equation for each trend line was determined and used in a correlation model. Finally, 40 plans verified the treatment time computation model - the real execution time was compared with our estimation and irradiation time calculated based on the equation provided by the manufacturer.

Results: A linear trend function was drawn and the Pearson correlation coefficient r were calculated for each of the 8 trend lines corresponding to the adequate treatment plan. An equation to correct the model was determined to estimate more accurately the beam-on time for different MFs. Correlation was found to be high since for all plans r was higher than 0.98. The data showed that the estimation suggested by the manufacturer tended to underestimate the beam-on time on average by 52sec. However, differences of up to 154sec were observed. Whereas, the estimation based on the correlation model overestimated the treatment time on average by 14sec. In Figure 1B, an advantage of the correlation model might be observed, since the most frequent beam-on time differences were below 10% and the data were distributed almost symmetrically (skewness=- 0.08) which might suggest a good assessment of our model.

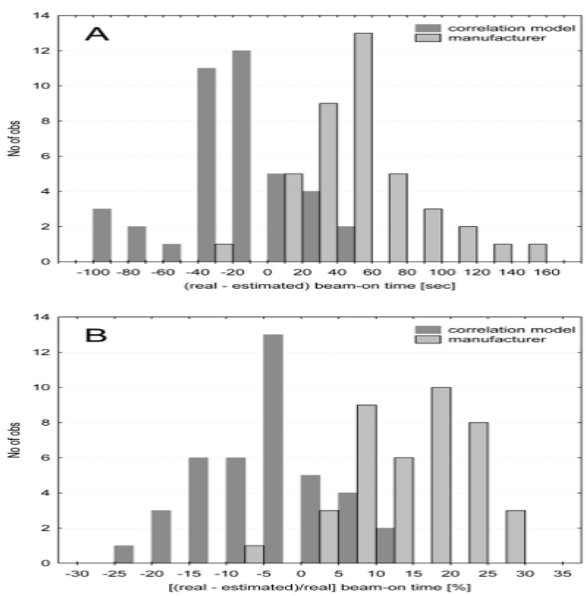

Figure 1. Histogram of differences between real (from HT system) and estimated (from correlation model or manufacturer equation) beam-on time in seconds (A) and percentage (B).

Conclusions: Our study showed that the model can well predict the treatment time for a given TL, MF, FW and it can be used in clinical practice.

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Commissioning and developing the use of 6MV flattening filter free

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Purpose/Objective: To discuss key points identified during the commissioning of 6MV flattening filter free (FFF) and to identify treatment sites routinely treated using RapidArc© (Varian Medical Systems, Palo Alto) that could benefit from 6MVFFF.

Materials and Methods: 6MVFFF was calibrated on the TrueBeam® linear accelerator (Varian Medical systems, Palo Alto) following the UK photon code of practice and the recommendations of Xiong et al (2008). Beam data was collected and the beam model configured in the Varian Eclipse TPS. The beam model was compared to measured data. Equipment routinely used for quality assurance, including the seven29 array (PTW, Freiburg), was tested in the high dose rate 6MVFFF beam. To identify sites which may benefit from FFF a number of prostate and multi dose level head and neck patients were replanned using RapidArc© with 6MVFFF and 6MV flattened beams. All plans were optimised to produce clinically acceptable plans based on departmental protocols. For each plan the conformity index and homogeneity index were calculated and site specific organ doses were compared.

Results: The 6MVFFF beam has been successfully calibrated with a correction of -0.5% being applied to k_Q. The seven29 array with Octavius phantom can accurately measure dose at a dose rate of 1400MU/min provided the measurement interval is adjusted to 200ms, but the QA BeamChecker™ Plus (Standard Imaging, United States) saturates at dose rates of 1400MU/min. However it is capable of accurately measuring at 1200MU/min.

For standard prostate RapidArc treatments table one demonstrates there is no clinical benefit in using 6MVFFF over 6MV. All organs were within the departmental tolerances with no individual organ benefitting significantly from the FFF beam. For head and neck patients it seems there may be a benefit in using 6MVFFF. For organs further away from the PTV it is easier to meet the dose constraints and maximum doses in these organs are lower. This is due to the natural shape of the beam. For organs close to the PTV it is often possible to reduce the maximum dose as well.

	Average conformity index PTV1	Standard deviation	Average conformity index PTV2	Standard deviation	Average homogeneity index PTV1	Standard deviation	Average homogeneity index PTV2	Standard deviation
6MV	1.06	0.004	1.14	0.05	1.06	0.004	1.06	0.0003
6MVFFF	1.10	0.07	1.13	0.04	1.06	0.002	1.06	0.0003

Table 1: Comparison of conformity index and homogeneity index for prostate treatments planned with 6MV flattened and FFF beams

Conclusions: Further guidance on the calibration of these beams and possibly the development of a calibration procedure in FFF beams is necessary. Existing equipment can be successfully used in these high dose rate beams although it is sometimes necessary to limit the dose rate.

Initial data suggests that FFF beams won't benefit standard prostate treatments, but may help reduce the maximum dose to critical organs in head and neck treatments.

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Implementation of an advanced treatment planning algorithm in the treatment of lung cancer

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Purpose/Objective: Modern TPSs are coming with advanced dose calculation algorithms such as superposition. However, when using superposition algorithms it is more difficult to achieve ICRU 50 recommendations (i.e. a minimum of 95% of the prescribed dose to the PTV) than with the old pencil beam convolution based algorithms due to the more accurate representation of the dose in heterogeneous media. The aim of this study was to determine the differences of dose calculations in lungs between two algorithms, and compare the calculations to measured doses.

Materials and Methods: Semi-anthropomorphic phantom CIRS Thorax 002 LFC was CT scanned and transferred to TPS. The phantom is elliptical in shape and represents an average human torso in proportion, density and two-dimensional structure. Plans were calculated according to IAEA TECDOC 1583 for verification of TPS, and measurements with ion chamber were conducted afterwards. Also, comparison of dose calculations for different clinical lung treatment plans were carried out for further 10 patients. Patient plans were calculated by both algorithms, but irradiated according to the results of the superposition algorithm. Also, old patient plans, clinically calculated and irradiated according to pencil beam calculations, were re-calculated by superposition, and differences evaluated.

Results: The systematic dose overestimation by up to 15 % for the pencil beam convolution algorithm was recorded for all measurement points located inside the lung equivalent material. The range of